

# Distinguishing Realistic Military Blasts from Firecrackers in Mitigation Studies of Blast Induced Traumatic Brain Injury

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## **Distinguishing Realistic Military Blasts from Firecrackers in Mitigation Studies of Blast Induced Traumatic Brain Injury\***

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In their Contributed Article, Nyein et al. (1,2) present numerical simulations of blast waves interacting with a helmeted head and conclude that a face shield may significantly mitigate blast induced traumatic brain injury (TBI). A face shield may indeed be important for future military helmets, but the authors derive their conclusions from a much smaller explosion than typically experienced on the battlefield.

The blast from the 3.16 gm TNT charge of (1) has the following approximate peak overpressures, positive phase durations, and incident impulses (3): 10 atm, 0.25 ms, and 3.9 psi-ms at the front of the head (14 cm from charge), and 1.4 atm, 0.32 ms, and 1.7 psi-ms at the back of a typical 20 cm head (34 cm from charge). The peak pressure of the wave decreases by a factor of 7 as it traverses the head. The blast conditions are at the threshold for injury at the front of the head, but well below threshold at the back of the head (4). The blast traverses the head in 0.3 ms, roughly equal to the positive phase duration of the blast. Therefore, when the blast reaches the back of the head, near ambient conditions exist at the front. Because the headform is so close to the charge, it experiences a wave with significant curvature.

By contrast, a realistic blast from a 2.2 kg TNT charge (~ an uncased 105 mm artillery round) is fatal at an overpressure of 10 atm (4). For an injury level (4) similar to (1), a 2.2 kg charge has the following approximate peak overpressures, positive phase durations, and incident impulses (3): 2.1 atm, 2.3 ms, and 18 psi-ms at the front of the head (250 cm from charge), and 1.8 atm, 2.5 ms, and 16.8 psi-ms at the back of the head (270 cm from charge). The peak pressure decreases by only a factor of 1.2 as it traverses the head. Because the 0.36 ms traversal time is much smaller than the positive phase duration, pressures on the head become relatively uniform when the blast reaches the back of the head. The larger standoff implies that the headform locally experiences a nearly planar blast wave. Also, the positive phase durations and blast impulses are much larger than those of (1).

Consequently, the blast model used in (1) is spatially and temporally very different from a military blast. It would be useful to repeat the calculations using military blast parameters.

Finally, (1) overlooks a significant part of (5). On page 1 and on page 3, (1) states that (5) did not consider helmet pads. But pages 3 and 4 of (5) present simulations of blast wave propagation across an ACH helmeted head form with and without pads. (5) states that when the pads are present, the "underwash" of air under the helmet is blocked when compared to the case without. (1) reaches this same conclusion, but reports it as a new result rather than a confirmation of that already found in (5).

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- (1) Nyein M.K., Jason A.M., Yu. L., Pita C.M., Joannopoulos J.D., Moore D.F., Radovtitzky R.A. 2010, In silico investigation of intracranial blast mitigation with relevance to military traumatic brain injury, PNAS, **107**, 20703.
- (2) Nyein M.K., Jason A.M., Yu. L., Pita C.M., Joannopoulos J.D., Moore D.F., Radovtitzky R.A. 2011, Correction for In silico investigation of intracranial blast mitigation with relevance to military traumatic brain injury, **108**, 433.
- (3) Design and Analysis of Hardened Structures to Conventional Weapons Effects, UFC 3-340-01 (TM 5-855-1) (2002).
- (4) Bowen, I.G., Fletcher E.R., and Richmond, D.R., 1968, Def. Atomic Support Agency, DASA-2113 DOD, Washington, DC.
- (5) Moss, W.C., King, M.J., Blackman, E.G., 2009, Skull Flexure from Blast Waves: A Mechanism for Brain Injury with Implications for Helmet Design Phys. Rev. Lett., **103**, 108702.